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Fort Detrick
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PLANT SCIENCES LABORATORIES

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ABSTRACT

Eighteen micrograms of 4-amino-3,5,6-trichloropicolinic acid (picloram) were applied to one primary leaf of each 10-day-old Black Valentine bean plant growing in an environmental chamber at 25 C and 50 to 60% RH. The source of the herbicide was then removed by excising all treated leaves at intervals from 15 minutes to 48 hours after treatment. Plants were harvested 14 days after treatment.

A marginal 10 to 15% inhibition of height occurred in the 15-minute group of plants. However, the 30-minute uptake period was sufficiently long enough to cause a statistically significant suppression of height. The first epinastic effects occurred within 10 to 12 hours after treatment. This time interval was essentially independent of the length of time allowed for export of the herbicide from the donor leaf for all treatment periods of 2 hours or longer. The severity of injury did not increase with uptake periods greater than 12 hours when evaluated by plant height. Injury, as reflected by a decrease in oven-dry weight, however, did increase with each period greater than 12 hours. This seemingly anomalous effect was caused by the severe injury or death of the terminal bud in all of the treatment groups equal to or longer than 12 hours.

I. INTRODUCTION*

The rapidity with which a herbicide is absorbed and translocated within a plant is of considerable interest since this is directly related to its ultimate phytotoxicity. Because 4-amino-3,5,6-trichloropicolinic acid (picloram) has become important as a herbicide and little is known about it in comparison with other herbicides such as 2,4-dichlorophenoxyacetic acid (2,4-D), it was considered important to obtain information concerning its absorption and translocation. This study is an attempt to determine how rapidly picloram is absorbed and mobilized within the bean plant.

II. METHODS AND MATERIALS

Phaseolus vulgaris L. var. Black Valentine beans were grown in a walk-in growth chamber in 1-quart pots of soil under the following environmental conditions: 25±1 C, 55±5% RH, and 1,200±100 ft-c with a 16-hour day and 8-hour night. The light source was a mixture of fluorescent and incandescent lamps.

When the plants were 10 days old they were treated on one primary leaf with 18 µg of picloram by application of five 10-µl drops of solution that contained 0.2% Tween 20. The source of the herbicide was removed from the plant by excising the treated primary leaf at various intervals from 15 minutes to 48 hours after treatment. For comparative purposes, the treated leaves were not excised from one group of plants. One primary leaf was also excised from each control plant. All plants were harvested 14 days later.

III. RESULTS AND DISCUSSION

Visual observations of plant responses 14 days after treatment and leaf excision indicated that an uptake period of 2 to 4 hours was required for picloram to be absorbed and translocated out of the treated leaf such that characteristic epinastic symptoms of picloram injury were evident. However, inhibition of growth in height was quite evident for those two treatment periods (Fig. 1). The 4-hour uptake period resulted in an approximate 50% inhibition of growth (Table 1).

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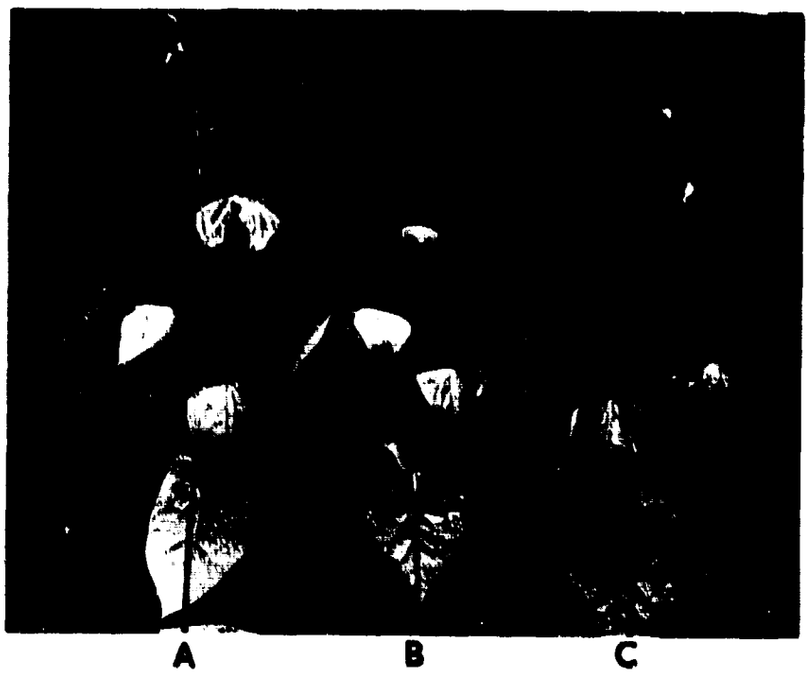

FIGURE 1. Inhibition of Growth of Black Valentine Beans 14 Days after 18 μg of Picloram in 0.2% Tween 20 were Applied to One Primary Leaf. The treated leaves were excised at indicated time intervals following treatment: A, control; B, 2-hour uptake period; and C, 4-hour uptake period.

TABLE 1. EFFECT OF LENGTH OF UPTAKE PERIOD FOR ABSORPTION AND TRANSLOCATION OF PICLORAM ON SUBSEQUENT GROWTH OF BLACK VALENTINE BEANS

Treatment Period, hours[a]	Height ± SE, cm[b]	Inhibition of Growth, %
Control	46.9±2.9[a]	0
¼	43.2±5.1[ab]	8
½	39.6±3.7[b]	16
1½	30.0±5.3[c]	36
2	27.8±3.4[c]	41
4	24.6±3.0[c]	48
12	15.5±2.4[d]	67
16	12.6±0.7[d]	73
24	13.4±1.1[d]	72
48	14.8±1.7[d]	68

a. Five 10-µl drops of solution were applied to one primary leaf that was then excised at the indicated time intervals.

b. Values are the average of four replications followed by the standard error of the mean. Values followed by the same superscript letter are not significantly different.

The plants in the 12-hour uptake group were of interest because their harvest weights (fresh and oven-dry) were greater than those of the controls, yet their growth in height was severely inhibited. The explanation for this seemingly anomalous result was found in the fact that their terminal buds were dead and there was an accompanying increase in axillary growth from most of the nodes (Fig. 2). This apparently resulted from loss of apical dominance following death of the terminal bud. The terminal buds were dead in all plants exposed to picloram for periods greater than 12 hours. However, only the 16-hour uptake group had axillary growth. As judged by the foliar symptoms, thickened stems, and massive callus formations, the amount of picloram in the tissue of these plants was so great that the axillary buds were inhibited. These observations are further evidence for the auxin-like properties of picloram.

FIGURE 2. Black Valentine Bean 14 Days after a 12-Hour Uptake Period of 18 μg of Picloram in 0.2% Tween 20. Herbicide was applied to one primary leaf that was excised 12 hours later. Note proliferation of axillary growth and cessation of terminal growth.

The height of the plants in the 15-minute treatment was not significantly different from that of the controls (Table 1), but the 30-minute treatment was significantly different. It is thus quite apparent that picloram is very rapidly absorbed and exported from the treated leaves of Black Valentine bean plants. When the height data are plotted against time, it can be seen that absorption and translocation is precisely linear from 15 minutes to 2 hours (Fig. 3). The inflection point in the response occurred at 2 hours. For uptake periods greater than 2 hours, the rate of absorption and transport decreases with time.

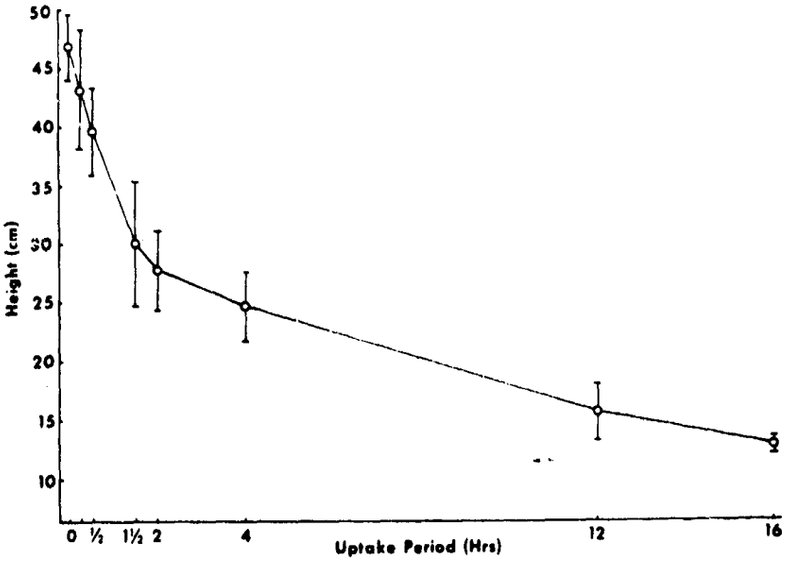

FIGURE 3. Relationship Between Increment of Time for Absorption and Export of 18 μg of Picloram from the Primary Leaf of a Bean Plant and Growth in Height. Treated leaves were excised at indicated time periods on the abscissa and the plants were harvested 14 days after time zero.

FIGURE 4. Inhibition of Growth of Black Valentine Beans 14 Days after 18 µg of Picloram in 0.2% Tween 20 were Applied to One Primary Leaf. The treated leaves were excised at indicated time intervals following treatment: A, control; B, 24-hour uptake period; C, 48-hour uptake period; and D, treated leaf not excised.

The visual effect of the 24- and 48-hour uptake period may be seen in Figure 4. These two treatments caused approximately 70% inhibition in growth in height. The most phytotoxic treatment in this study was the one in which the treated leaves were never excised (Fig. 4). The only logical interpretation for this unexpected finding is that picloram continues to be absorbed and exported from the leaves of bean plants after 48 hours have elapsed since application of the treatment. It should be clearly understood that these studies do not differentiate between the processes of absorption and translocation and that they must be viewed as one process because of the nature of the methods used to obtain these data.

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